TRANSIENT EVOKED OTOACOUSTIC EMISSIONS IN FULL-TERM AND PRETERM NEWBORNS

Emissões otoacústicas evocadas transientes em recém-nascidos a termo e pré-termo

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ABSTRACT

Purpose: to evaluate and compare the amplitude of transient evoked otoacoustic emissions, observing the variables gender and ear in preterm and term newborns with and without hearing impairment risk. **Methods:** the group studied consisted of 156 newborns of both genders, aged up to 54 post-conceptional weeks, allocated into three groups according to their gestational age. Group G1 was composed of 83 term newborns and G2 of 73 preterm infants. The latter was subdivided into G2A, composed of 42 newborns without hearing loss risk and G2B of 31 newborns at risk. The transient evoked otoacoustic emissions were obtained by nonlinear click stimulus presented at 84 dB SPL with the Echocheck ILO OAE Screener, Otodynamics. For data analysis, the following statistical tests were used: Mann-Whitney, chi-square or Fisher exact test, Kruskal-Wallis ANOVA and Dunn multiple, post marked Wilcoxon with p< 0, 05 was considered significant. **Results:** the amplitude of the transient evoked otoacoustic emissions was greater in G1 (p= 0.017) than in G2 (p= 0.048) in the right and left ear and these difference was significant. Group G1 (p = 0,009) presented statistically greater amplitude in otoacoustic emissions than G2B in the right ear. **Conclusion:** the term group presented greater amplitude in otoacoustic emissions than the pre-term group. No difference in otoacoustic emissions was observed in the variables gender or ear.

KEYWORDS: Otoacoustic Emissions; Audiology; Infant, Newborn

INTRODUCTION

Over the last few decades, audiological investigation in newborns has been made possible using objective clinical procedures that enable the diagnosis of auditory disorders in the first days of life. The discovery of the phenomenon of otoacoustic emissions made by Kemp[1]and the possibility to register them through the mechanical activity of the outer hair cells (OHC) has enabled an advancement in the field of cochlear physiology. The OHCs are innervated by efferent fibers of the medial olivocochlear system (MOCS) and are, at the same time, rigid in order to maintain their structure and flexible so as to enable stretching and shortening in a rapid contraction. This contraction elicits wave amplification and a mechanical force towards the external auditory canal, where they may be captured in the form of OAE[2] which may be spontaneous or evoked.

A study suggests that the outer hair cells (OHC) become capable of synapsing with the efferent system only after the 22nd week of pregnancy. Thus, the authors believe that the cochlea has not yet reached its functional maturity before the 22nd week and that, the end of this maturation process should probably occur during the pregnancy's last trimester[3], or, from the 28th week onwards. Another study found the presence of otoacoustic emissions beginning at 27 weeks gestational age[4].

Evoked otoacoustic emissions (EOAE) are registered after sound stimulation that may be transient (TEOAE) produced by click signals, that are short lasting with a very wide frequency range and the

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distortion product otoacoustic emissions (DPOAE), generated by two simultaneous pure tones in specific frequencies[2]. The most widely recommended technique for use in neonatal screenings has been the transient evoked otoacoustic emissions (TEOAE) using Quickscreen mode, with the non-linear stimulus as it is of weak intensity and is more rapid[5].

Many scientific studies in both national and international literature have been conducted using EOAE in preterm and full-term newborns, with and without risk for hearing loss[4-12], however with different methodological procedures among them. Some authors observe greater amplitude of the EOAE in full-term newborns when compared to preterm[10-12]. In one longitudinal study, when observing the changes in response levels of the TEOAE with the increase in postconceptional age, in premature babies – according to gestational age (30 weeks), the authors suggested that the maturational process is not modified from the 38th week onwards. It has also been observed that the amplitudes of OAE in children are much greater than in adults[13]. However, another study with newborns before and after the 38 week postconceptional period showed an increase in the TEOAE after 38 weeks, indicating that the maturation process of the active mechanisms of the cochlea and the properties of the middle ear occurs after the 38th week[14].

In a study of 96 children younger than 12 months of age, with and without auditory risk, the authors have verified that the amplitude of the TEOAE was lower in the auditory risk group and the presence of emissions occurred in higher percentage in the group without auditory risk. The researchers have concluded that the auditory risk index influenced the incidence and the presentation of the amplitudes of the transient evoked otoacoustic emissions[15].

Other authors have studied transient otoacoustic emissions in 44 newborns: 22 with auditory risk indicators, with postconceptional age in between 8 and 65 days of life; and 22 newborns without auditory risk indicators, with postconceptional age in between 7 and 30 days of life. The obtained results showed an expressive difference between the infants, with inferior performance of the newborns with auditory risk indicators, regarding parameters of wave reproducibility, general and specific amplitude[16].

The transient evoked otoacoustic emissions were also studied by other authors[7]in 526 newborns, 440 of whom were born at full-term and 86 preterm. The results show that the amplitudes were greater in the right ear and, the higher the postconceptional age, the greater the response amplitude of the TEOAE. The amplitude parameter in the TEOAE provides evidence of the presence of otoacoustic emissions, and is thus considered by these authors as an indicator of maturity of the peripheral auditory system in newborns. Similar findings were observed in another study[8]where 50 full-term and 50 preterm newborns with postconceptional ages varying in between 24 hours and 11 weeks of life were evaluated. It was observed that the amplitudes of the right ear were greater than those of the left ear and the greater the conceptional age, the greater the amplitude of the emissions.

Given the diversity of the samples and the results found in the studies conducted by several authors, there is a need for further investigations on the subject of time of functional maturity of the outer hair cells, thus contributing to the production of knowledge in the field of clinical audiology.

The present study was conducted with the purpose to compare the amplitude of the transiente evoked otoacoustic emissions, observing the variables of gender and ear, as well as the risk factors for hearing disorder in full-term and preterm newborns, with and without risk for hearing disorders.

METHODS

This study was submitted to the Research Ethics Committee at the Veiga de Almeida University (UVA) and was approved under protocol number 258/10.

This is a prospective, cross-sectional, experimental study. Data collection was conducted at the Audiology Department of the National Institute of Education for the Deaf, INES. The newborns' caregivers were invited to participate in the study, after having been informed of its volunteer characteristic and of its methodological procedures.

The study's sample was composed of 156 newborns, of both genders – 62 females and 94 males -, of which 83 were full-term and 73 preterm with a minimum of 8 days of life and a maximum of 54 postconceptional weeks. In order to select the sample, information about pregnancy time were collected and questions based on the questionnaire by the Joint Committee on Infant Hearing (2007)[17], concerning the main risk factors for hearing disorders were asked.

The main risk factors were: Family history of deafness, history of congenital infections (syphilis, toxoplasmosis, herpes, rubella, and cytomegalovirus); bacterial meningitis, syndrome characteristics, craniofacial anomalies with ear canal and earlobe disorders; mechanical ventilation assistance >5 days; prematurity; low birth weight (<1500 kg); maternal/fetal blood incompatibility; hyperbilirubinemia with transfusion of blood-based products BL > 15 ME / 100 ml; ototoxic medication administration for longer than 5 days, including aminoglycosides, associated or not associated to diuretics; and severe asphyxiation with Apgar 0-4 in the 1st minute or 0-6 in the 5th minute. Based on the gestational age reported during the interview, two different groups were formed: the full-term group, referred to in this study as G1 – with birth in between 37 and 42 weeks – and the preterm group, called G2 – with birth in between 26 and 37 weeks. The newborns with absence of risk indicators for hearing disorder in their clinical history, or negative answers to the questions in the interview were included in this study. The preterm (G2) newborns were divided into two subgroups, called G2A and G2B. G2A was composed of the preterm newborns without risk for hearing disorders; or, those who did not present any of the risk indicators for deafness. G2B was composed of the preterm newborns at risk for hearing disorders; or, those who had at least one risk factor for deafness according to the answers to the interview.

The evaluation took place in a room with acoustic treatment, while the newborn was asleep in the arms of the caregiver who was seated comfortably in a chair with arm rests.

The TEOAE were obtained using the ILO ECHOCHECK – OAE, Screener, Otodynamics equipment, non-linear click stimulus in an intensity of 84 dB SPL, in the frequency range from 1500 to 3000 Hz. The first ear to be tested was randomly selected, and the one with easier access was preferred, in order to avoid the newborn to be woken.

As an analysis criteria of the amplitude of the otoacoustic emissions, only the amplitude of the general response was selected, and the signal/noise ratio was studied, using a response value greater than or equal to 6 dB SPL[7].

The newborns who failed the TEOAE, or, those who had general response amplitude (signal/noise ratio) under 6dB, were excluded from the study and referred to immitanciometry and to Brainstem Auditory Evoked Potential examination.

Following their collection, the observed data were presented as a table and the values expressed in mean, standard deviation, median, minimum and maximum. The following procedures were used for statistical analysis:

- the Mann-Whitney test in order to compare the TEOAE in between both groups of newborns;
- Kruskal-Wallis ANOVA test to compare the TEOAE of the three subgroups of newborns and Dunn's multiple comparisons test (non-parametric), that identified the subgroups that were significantly different from one another;
- Wilcoxon signed rank test for the variation of TEOAE between the left and right ears.

Non-parametric tests were conducted since the variables did not have normal distribution, due to the dispersion of the data, the distribution's lack of symmetry and rejection of the normality hypothesis, according to the Kolmogorov-Smirnov test for some subgroups.

In this study, the level of significance was set at 0.05 (5%) and the statistical analysis was processed using the SAS 6.11 software (SAS Institute, Inc., Cary, North Carolina). All p values considered statistically significant according to the level of significance defined were signaled with an asterisk (*).

RESULTS

Initially, the descriptive analysis of groups G1 and G2 (Table 1) and of groups G2A and G2B (Table 2) will be shown. Gestational, chronological and postconceptional ages were studied. It was observed that the gestational age was significantly greater for the group not at risk in relation to the group at risk (G2B) (Table 2).

Table 1 – Descriptive analysis of groups G1 and G2 according to gestational, chronological and postconceptional ages

Group	Variable	Mean	SD	Median	Minimum	Maximum
G1 (n = 83)	Gestational age (weeks)	39.2	1.3	39	37	42
	Chronological age (days)	45.9	17.6	49	7	84
	Postconceptional age (weeks)	45.8	2.9	46	38	52
G2 (n = 73)	Gestational age (weeks)	33.9	2.5	35	26	36
	Chronological age (days)	66.4	37.1	58	17	200
	Postconceptional age (weeks)	42.9	4.8	41	34	54

SD: Standard Deviation
t-Student test, Mann-Whitney test

Table 2 – Analysis of gestational, chronological and postconceptional ages in the group of preterm newborns (G2), according to the presence (G2A) and absence (G2B) of risk factors

Age	Group	Mean	SD	Median	Minimum	Maximum	*p value*
Gestational (weeks)	**G2A**	34.6	2.0	35	28	36	**0.005***
	G2B	32.9	2.8	33	26	36	
Chronological (days)	**G2A**	61.8	32.9	54	17	148	0.27
	G2B	72.7	41.8	62	20	200	
Postconceptional (weeks)	**G2A**	42.9	4.6	42	34	54	0.95
	G2B	42.9	5.0	41	36	54	

SD: Standard Deviation
t-Student test, Mann-Whitney test

In regards to the amplitude of the TEOAE, there is no significant difference among the variables gender and ear (Table 3).

It was observed that the amplitude of the TEOAE for group G1, full-term newborns, was significantly greater than that of group G2, preterm newborns, in both ears, right (p= 0.017) and left (p = 0.048). The performance of Wilcoxon Signed Rank test showed that there is no significant variation in the TEOAE (in DB) in between right and left ears (Table 4).

Table 3 – Analysis of the transient evoked otoacoustic emissions (in dB) of the right and left ears, according to the variable gender (female and male)

Variable		Gender	Mean	SD	Median	Minimum	Maximum	*P-value*[a]
Right era	OAE	Male	18.4	5.1	19	8	30	0.60
		Female	18.9	4.8	18.5	10	30	
Left ear	OAE	Male	17.7	5.1	18	6	27	0.28
		Female	18.6	4.4	19	8	30	

SD: Standard Deviation
[a]Mann-Whitney test

Table 4 – Analysis of the amplitude of the transient evoked otoacoustic emissions (in dB) of the right and left ears, according to the variable group

Variable		Group	Mean	SD	Median	Minimum	Maximum	*p-value*[a]
Right ear	OAE	**G1**	19.5	4.7	19	9	30	**0.017***
		G2	17.6	5.2	18	8	30	
Left ear	OAE	**G1**	18.8	4.4	19	9	28	**0.048***
		G2	17.3	5.3	18	6	30	

[a]Mann-Whitney test.

The Kruskal-Wallis ANOVA test showed that there is a significant difference in the TEOAE of the right ear (p = 0.009) between the subgroups G1, G2A and G2B.

The Dunn test showed that the group of preterm newborns at risk, G2B, had significantly smaller amplitude of the TEOAE in the right ear than the G1 full-term group. There was no significant difference in the right ear between the subgroups of preterm not at risk, G2A and preterm at risk, G2B, and in between preterm not at risk, G2A, and full-term newborns, G1. There was no significant difference in the left ear, at a level of 5% between the subgroups preterm newborns not at risk G2A and preterm newborns at risk, G2B, and in between preterm newborns not at risk G2A and full-term newborns, G1 (Table 5).

Table 5 – Analysis of the amplitude of the transient evoked otoacoustic emissions of the right and left ears, according to the variable subgroups

Variable		Group	Mean	SD	Median	Minimum	Maximum	*p-value*[a]
		G1	19.5	4.7	19	9	30	
Right ear	OAE	**G2A**	18.5	5.4	18.5	8	30	**0.009***
		G2B	16.3	4.8	16	9	28	
		G1	18.8	4.4	19	9	28	
Left ear	OAE	**G2A**	17.7	4.9	18	9	27	0.11
		G2B	16.7	5.8	16	6	30	

SD: Standard Deviation
[a]Kruskal-Wallis' ANOVA.

In regards to the variable ear, there was no significant variation of the TEOAE in each studied group and in the sample total.

DISCUSSION

It is thought that premature infants require more care and interventions than those born full-term, and are, therefore, more vulnerable to auditory disorders. Authors[4]have stated that prematurity constitutes a potential risk factor for the presence of auditory disorder, and may also be associated to delay in cochlear maturity and in the myelination of the auditory pathways[7]. Therefore, this fact shows a need to verify cochlear function in preterm newborns.

According to the descriptive statistical analysis, the sample characterization evidenced that the gestational age of G1 was greater than that of G2, which was expected, considering the method employed in this study. The mean gestational age of G1 was 39.2 weeks and of G2 33.9 weeks, a result that is similar to those in other studies[5,9,12]. Regarding chronological age, it was observed that the subjects in G2 were evaluated later than those in G1, possibly due to the period spent in the Intensive Care Unit (ICU), where the newborns in G2 were subject to staying. Comparing the mean postconceptional ages of G1 (45.8 weeks) and of G2 (42.9 weeks), it is observed that, in both groups, the mean postconceptional age was greater than 40 weeks on the day that testing was conducted.

When analyzing age according to the presence of risk indicators for auditory disorders in between groups G2A and G2B, group G2B had significantly younger gestational age (0.005). This difference may be due to the fact that the participants in this group are more premature and, therefore, are more at risk for auditory disorders. However, the statistical findings express that most newborns in both groups (G2A and G2B) were the same postconceptional age when assessed (42.9 weeks), independently of the presence of risk indicators for auditory disorder. This fact differs from studies conducted by other authors[5,8] in which the mean postconceptional age in preterm newborns was 36.4 weeks, a younger age than in the present study.

In the general sample, when analyzing the amplitude of the TEOAE, according to the variables gender and ear, the mean profiles of the amplitudes show very close values, for both variables, independently of the group, G1 or G2.

Whether or not in accordance with the present study, other studies were selected from the available literature, where several methodological differences may be observed, mainly referring to gestational age and test protocols employed (types of clicks and intensity). The results of the TEOAE will be described according to the variables gender and ear, as shown in Figure 1.

Amplitude of TEOAE according to sex/ear	N	Sample Category	Encoutered Results	Agree with the present study	Disagree with the present study
Aidan et al. 1997	582	Not at risk	Greater amplitude in F sex and greater amplitude in RE		
Costa e Costa Filho 1998	42	Preterm	No difference in amplitude according to sex and ear		
Durante e Carvallo 2001	25	Full-term not at risk	Greater amplitude in F sex and greater amplitude in RE		
Denzin et al. 2002	44	At risk and not at risk	Greater amplitude in RE and no difference according to sex		
Bassetto et al. 2003	526	Full-term and preterm	Greater amplitude in RE, variable sex was not studied		
Costa et al. 2009	50	Preterm	No difference in amplitude according to sex and ear		
Melo et al. 2010	100	Full-term, preterm at risk and not at risk	Greater amplitude in RE, variable sex was not studied		
Present study	156	Full-term, preterm at risk and not at risk	No difference in amplitude according to sex and ear		

RE = right ear; F= Female

Figure 1 – Description of the studies of TEOAE in preterm and full-term babies according to the variables gender, ear and risk factors for auditory disorders.

The amplitudes of G1 and G2 proved similar in both ears. Both G1 and G2 had minimum values of 6 dB (signal-noise level) for the TEOAE. The maximum values were the same in the right ear of both groups; they were, however, higher in the left ear in the preterm group. It was observed that some premature newborns reached amplitudes as robust as those born full-term. This finding shows that the cochlea's functional maturity occurs in the last trimester of pregnancy, as suggested by other authors[3].

When comparing the mean TEOAE amplitude values in between the groups, in both ears it is seen that the mean amplitude of emissions was significantly lower in G2 than in G1. Similarly, some studies[7,8] have also reported differences in the TEOAE amplitudes of full-term and preterm newborns. However, this finding is different from the ones in the study by Goforth[18] that found opposite results, even though the analyzed groups were similar.

The parameter of amplitude of the EOAE may be considered a signo f maturity of the peripheral auditory system of newborns, since it provides evidence of teh presence of emissions[7].

The process of maturity of the cochlea's active mechanisms and of the properties of the middle ear occur alongside the increase in the emissions after 38 postconceptional weeks, fact that justifies lower emissions in premature babies assessed before this time period[14].

The maturity of cochlear structures of full-term and preterm newborns in the postnatal phase was observed in one study, due to the increase in the amplitude of the TEOAEDP in the period in between hospital discharge and 15 to 40 days later[19]. Other authors indicate that, the older the conceptional age, the greater the amplitude of the emissions[8]. However, there is divergence among literature findings, since the authors suggested that the process of maturity is not modified from the 38th week onwards[13].

When comparing the means of the amplitudes of the TEOAE in the right ear, between G1, G2A and G2B, there was a statistically significant difference in between G2B and G1 (Table 5). G2B had TOAE amplitude in the right ear that was significantly smaller than G1. Regarding the left ear, this difference was not observed. These data strengthen the findings of other authors[15,16] only in regards to the risk indicators, but they do not report differences between ears.

It is observed that the mean of the amplitudes of the emissions of preterm newborns at risk are lower than of those not at risk, but this difference is not statistically significant. Similar values regarding the mean amplitude of the emissions – around 16 dB SPL – were observed in another study[15].

There were divergences found in literature on the results of studies concerning the amplitudes of emissions in preterm newborns, with and without risk. Some authors[8]found results similar to the ones in the present study, indicating a similar functionality of the OHC in preterm newborns at risk and not at risk, as well as the absence of auditory disorder. Other authors[15] claim that there is a difference in emissions amplitudes between these groups.

CONCLUSION

Regarding the comparative analysis of the amplitudes of the TEOAE, it was observed that the preterm group, G2, had smaller TEOAE amplitude than the full-term group, G1.

The preterm at risk group, G2B, had smaller TEOAE amplitudes in the right ear than the full-term group, G1.

There was no difference in otoacoustic emissions regarding the variables gender and ear.

RESUMO

Objetivo: verificar comparativamente a amplitude das emissões otoacústicas evocadas por estímulos transientes, observando as variáveis gênero e orelha em recém-nascidos a termo e pré-termo com e sem risco para alterações auditivas. **Métodos:** participaram deste estudo 156 recém-nascidos, de ambos os gêneros, com idade pós-concepcional de até 54 semanas, alocados em três grupos de acordo com a idade gestacional. O G1 foi composto de 83 recém-nascidos a termo e o G2 de 73 pré-termo. Este último, subdividido em G2A, com 42 recém-nascidos sem risco para alterações auditivas e G2B com 31 recém-nascidos com risco. As emissões otoacústicas transientes foram obtidas com clique não-linear, à 84 dB NPS utilizando o Echocheck ILO EOA Screener, Otodynamics. Para análise dos resultados, foram utilizados os testes estatísticos: Mann-Whitney, qui-quadrado ou exato de Fisher, ANOVA de Kruskal-Wallis e múltiplas de Dunn, teste dos postos sinalizados de Wilcoxon; sendo considerado como significante o $p < 0,05$. **Resultado:** observou-se diferença significante nas amplitudes das emissões otoacústicas evocadas transientes, maior em G1 ($p= 0,017$) do que em G2 ($p=0,048$) na orelha direita e esquerda. O grupo G1 ($p= 0,009$) apresentou amplitude das emissões otoacústicas estatisticamente maiores que G2B na orelha direita. **Conclusão:** o grupo a termo apresentou amplitude das emissões otoacústicas maiores do que o grupo pré-termo. Não houve diferença das emissões otoacústicas entre as variáveis gênero e orelha.

DESCRITORES: Emissões Otoacústicas; Audiologia; Recém-Nascido

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